



## **“E–Diesel and Biodiesel: A Status Report to the Industry”**

**U.S. Department of Energy Fuel Ethanol Workshop**

**Presented by**

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## **Introduction**

### **AAE TECHNOLOGIES, INC.**

- Established in 1997, holder of numerous worldwide patents for fuel additive technologies
- O<sup>2</sup>Diesel™ efforts in U.S. underway since 1998 – focused on cost-effective, commercially viable products

### **OCTEL STARREON, LLC**

- Over 60 years as a leading world fuel additive supplier
- Leading manufacturer and supplier of diesel additives
- North American sales and distribution network for Performance & Petroleum Specialty Chemicals



## Introduction (continued)

### Western Ethanol Company LLC Regent International

- 20 years as an ethanol producer and distributor, both domestic and international.
- Detailed experience in shipping, storing, and delivering fuel ethanol throughout Europe and North America.
- Committed to identifying and developing new uses and markets for ethanol fuels.



## Diesel Market Overview

- Diesel emissions under scrutiny on a global level
- Global policies challenge operators, refiners and marketers
- Targeted emissions from diesel: NOx, CO, PM and air toxics
- Other solutions such as CNG, catalysts & DPFs are costly, some still untested, and many require major infrastructure changes
- Fleets affected include: urban transit vehicles, delivery & service fleets, construction and other off-road equipment
- U.S. market: ~50 billion gallons and growing (highly segmented)



## What is E-Diesel?

A diesel fuel containing conventional diesel blendstock(s) with:

- Up to 15 vol% Anhydrous Ethanol
- Stabilized with ~1.0 – 5.0 vol% proprietary additive(s), and
- Cetane enhancement where required

The AAE-Octel Starreon *Octimax™ 4931* (includes cetane improver) makes commercially viable O<sup>2</sup>Diesel™ at <1.0 vol% additive treat rate

- Premium Diesel performance – lubricity, stability, conductivity
- Little or no infrastructure or engine changes required
- Can be used in heavy-duty on- & off-road CI engines now!



## What is E-Diesel? (continued)

### Why Ethanol is an Ideal Diesel Oxygenate

- Benefits:
  - Renewable, domestic replacement for imported petroleum
  - No significant environmental side-effects
  - Widely proven as a gasoline oxygenate in world markets including USA, Canada & Brazil
  - Supply & infrastructure already exists in key global markets
  - Greenhouse gas reduction impacts

However, historically unable to 'blend' ethanol with diesel largely due to ethanol's hygroscopic nature -- *UNTIL NOW!*



## Emissions Benefits

### “Typical” E-Diesel Emissions Test Results

Colorado School of Mines: Nov. '99 – Dec. '00

EPA No.2 Diesel vs. No.2 O<sup>2</sup>Diesel™ (7.7vol% ethanol)

CO



20–28%

NO<sub>x</sub>



2–6%

PM



34–40%

BHP



–1 / +2%

EPA 13-mode Transient Cycle Engine Tests (1991 DDC Series 60)



## Summary: O<sup>2</sup>Diesel™ Fleet Testing



- Ease of logistics, distribution, and handling
- “Drop-in” clean fuel solution
- Little or no infrastructure or engine changes
- Excellent cold weather operability
- Visible and measurable emission benefits

- Good engine performance and driveability
- Fuel is fully fungible with regular diesel
- No reported mileage demerits (urban fleets)
- Economics better than alternative technologies
- No significant capital investment required





## Summary: O<sup>2</sup>Diesel™ Fleet Testing

- Nevada Ready Mix (Las Vegas, NV): Feb. 2000 – July 2001 (quarry trucks)
- Lincoln StarTran (Lincoln, NE): August, 2000 – current (urban buses)
- Pepsi-Cola (The Bronx, NY): Nov. 2000 – current (>200 delivery trucks)
- Zachry Const. (San Antonio, TX): Mar. 2001 – current (const. equipment)
- Pearl City Co-op (Pearl City, IL): June 2000 – current (fuel delivery trucks)
- Winnipeg Transit (Winnipeg, Manitoba): Oct. 2001– Aug. 2002 (20 buses)
- Citizen Area Transit (Las Vegas, NV): Started Nov. 2002 (17 urban buses)

*Also:*

- OCTranspo (Ottawa, Ontario): Starts 1st Qtr. 2003 (20 urban buses)
- 5 Municipalities (So. Calif.): Starts 1st Qtr. 2003 (120 diesel engines)



## E-Diesel Technical Agenda: 2002

- “Ethanol-Blended Diesel Fuel Handbook” -- initiated Summer, 2001 and to be completed Fall, 2002 (Argonne Nat’l. Labs)
- Uniform Safety and Handling procedures -- Evaluation underway in 2001/02 at Southwest Research Institute
- Greenhouse gas impact analysis -- initiated Summer, 2001 by Argonne Nat’l. Labs (Michael Wang, et al)
- Health effects testing req’d. per Section 211(b) of the Clean Air Act
- John Deere cooperative test program (>\$2 million + 2 years)



## E-Diesel Consortium: Organization

- Draft Consortium Charter approved Dec. 4, 2001
- Established under the Renewable Fuels Foundation
- Consortium began work in early 2002
- Significant technical & regulatory agenda (2002 – 03)
- Broad industry/government participation anticipated



## E-Diesel Consortium: Participants

- State of Illinois “Core Group” (original E-Diesel Task Force)
- Additive Suppliers (AAE Technologies/Octel Starreon, Akzo Nobel, GE/Betz, Lubrizol, Pure Energy Corp., etc.)
- Engine Manufacturers (John Deere, etc.)
- US Dept. of Energy (including NREL, Argonne National Lab)
- Renewable Fuels Association (U.S. and Canada)
- National Corn Growers Association (and state chapters)
- State and local, public & private groups (e.g., Nebraska Ethanol Board)



## E-Diesel Consortium: Technical Issues

- Managing flash point & flammability
- Determining materials compatibility & durability
- Establishing storage & handling requirements
- Meeting ASTM/CGSB fuel standards & acceptability (“Fill & Go”)
- Completing EPA health effects testing
- Obtaining additional emissions benefits
- Complying with federal, state & local laws & regulations



## Conclusions

### Challenges:

- E-Diesel faces a substantial technical & regulatory agenda
- Tax incentive issues must be addressed for full commercialization
- Meaningful public & private support for E-Diesel needed
- Major competition from other new diesel fuels & technologies expected
- OEM skepticism will be significant for a while to come

### But E-Diesel has *Momentum*.....

- E-Diesel Consortium is now in place to address all outstanding issues
- E-Diesel will be “ready for prime time” well before 2006 – 07!

## Biodiesel Overview

- What is Biodiesel?
- How is Biodiesel made?
- Biodiesel market
- Benefits of Biodiesel
- Biodiesel Challenges
- Ethanol and Biodiesel

## What is Biodiesel?

- Biodiesel (fatty acid alkyl esters) is a cleaner-burning diesel replacement fuel.
- Made from natural, renewable sources such as new & recycled vegetable oils and animal fats.
- Just like petroleum diesel, biodiesel operates in combustion-ignition engines.
- Blends of up to 20vol% biodiesel + 80vol% petroleum diesel fuels (B20) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment.
- Higher blends, even neat biodiesel (B100), can be used in many engines built since 1994 with little or no modification.

## How is Biodiesel Made?

- Biodiesel fuel can be made from “virgin” or recycled vegetable oils and animal fats, which are non-toxic, biodegradable, renewable resources.
- Fats and oils are chemically reacted with an alcohol (typically methanol, but ethanol is also used) and a catalyst to produce fatty acid methyl (or ethyl) esters and glycerine co-products.
- Biodiesel can be produced by a variety of esterification technologies.
- Approximately 50% of the U.S. biodiesel industry can use any fat or oil feedstock, including recycled cooking grease. The other half is limited to vegetable oils, the least expensive of which is soybean oil.

## Biodiesel Fuel Market

- The use of biodiesel has grown dramatically in the United State during the last few years. ( Currently about 25 mil. gallons per year ).
- The Energy Policy Act (EPACT) was amended in 1998 to include biodiesel fuel use as a way for federal, state, and public utility fleets to meet requirements for using alternative fuels.
- Biodiesel users include the U.S. Postal Service and the U.S. Departments of Energy and Agriculture. In addition, many school districts, transit authorities, national parks, public utility companies, and garbage and recycling companies also use the fuel.
- With sufficient government incentives, biodiesel sales could reach about 2 billion gallons per year, or about 8% of highway diesel consumption.

## Benefits of Biodiesel

- Every gallon of biodiesel displaces 0.95 gallons of petroleum-based diesel over its life cycle.
- Biodiesel reduces the amount of carbon dioxide (CO<sub>2</sub>) being released into the atmosphere.
- Biodiesel is nontoxic and biodegradable.
- Biodiesel can provide substantial lubricity benefits to premium diesel fuels.
- Biodiesel is an oxygenated fuel, so it contributes to a more complete fuel burn and a greatly improved emissions profile.
- Biodiesel reduces air toxics that are associated with petroleum diesel exhaust and are suspected of causing cancer and other human health problems.

## Challenges for Biodiesel

- Biodiesel currently costs between \$1 and \$2 per gallon to produce.
- Fats and greases cost less and produce less expensive biodiesel but feedstock costs alone are at least \$1.50 per gallon of soybean oil-based biodiesel.
- According to the National Renewable Energy Laboratory (NREL), there is only enough U.S. feedstock to supply 1.9 billion gals. of biodiesel.
- Biodiesel's fuel economy, torque, and power are somewhat less than diesel (8% to 15%) because of its lower energy content.
- Biodiesel derived from some feedstocks tends to increase NO<sub>x</sub> emissions.
- In colder weather, tank heaters or agitators may be required.



## Ethanol and Biodiesel

- Ethanol can be utilized to produce an *ethyl ester* (instead of a methyl ester derived from using methanol).
- Ethyl esters can have lower smoke opacity, exhaust temperatures and pour point temperatures than methyl esters.
- Ethyl esters meet the same ASTM standard specification for biodiesel as methyl esters (D6751)
- Ethanol is a preferred process alcohol compared to methanol because it is renewable and more environmentally benign.
- In Hawaii, recycled vegetable oils & ethanol represent the most promising biodiesel (ethyl ester) feedstocks due to their availability.
- For more Biodiesel information contact the National Renewable Energy Laboratory (NREL)



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